Seawater District Cooling Feasibility Analysis for the State of Hawaii – Summary of Results

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Presentation Overview

- Study Objectives
- Areas Evaluated
- Economic Analyses
  - Sensitivity Analyses
  - Case Study Results
- Other Benefits of SWAC Use

Presentation Overview (cont'd)

- Secondary Uses of SWAC Effluent
  - As a Heat Sink
  - Cool and Cold Water Aquaculture and Agriculture
  - Water Quality Improvement
- Conclusions
- Recommendations

Study Objectives

- Identify potential areas for SWAC applications (such areas include the downtown Honolulu area, Waikiki, Ala Moana Center, and large hotels or hotel clusters on each of the islands with good access to cold deep seawater)
- Update previous feasibility studies for SWAC (e.g., West Beach, Waikiki)
- Conduct preliminary technical and economic feasibility analyses for other promising locations in Hawaii

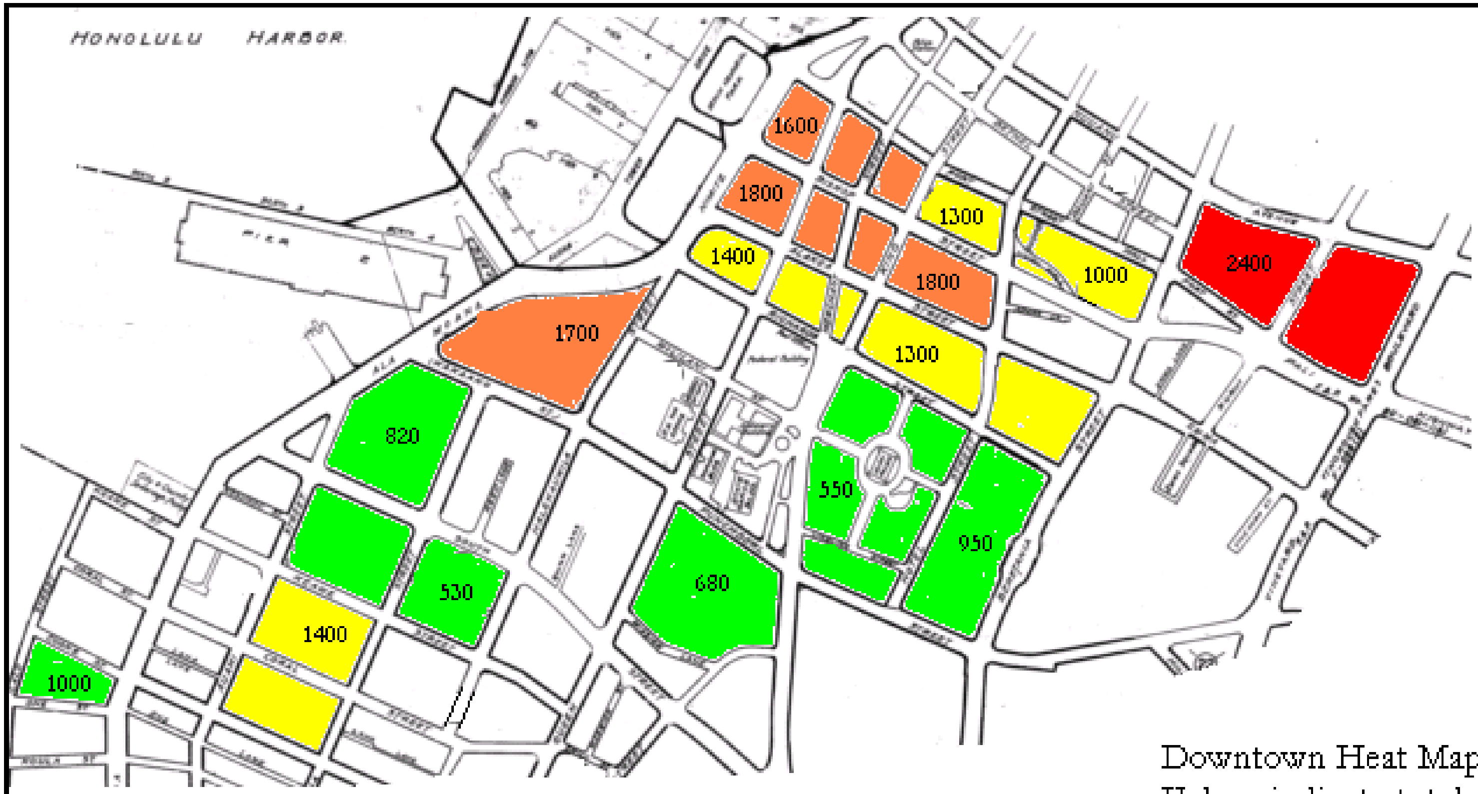
Study Objectives (cont'd)

- Prioritize these locations for further technical and economic analysis
- Develop a marketing plan to allow private sector development of one, or more, of these Hawaii projects
- Identify types of assistance that can be provided by the State of Hawaii (e.g., Special Purpose Revenue Bonds) and other government sources

Areas Evaluated

- Evaluations were conducted for six areas on Oahu, and four on the neighbor islands using a common set of economic parameters (base case analyses)
- On Oahu the primary demand areas are along the shores of Mamala Bay where it is difficult to get to the 3,300 foot (1,000 meter) depth required for 39^{o}F (4^{o}C) water. However, the 1,600-foot (500 meter) depth contour is within reach and consequently 45^{o}F (7^{o}C) water is available

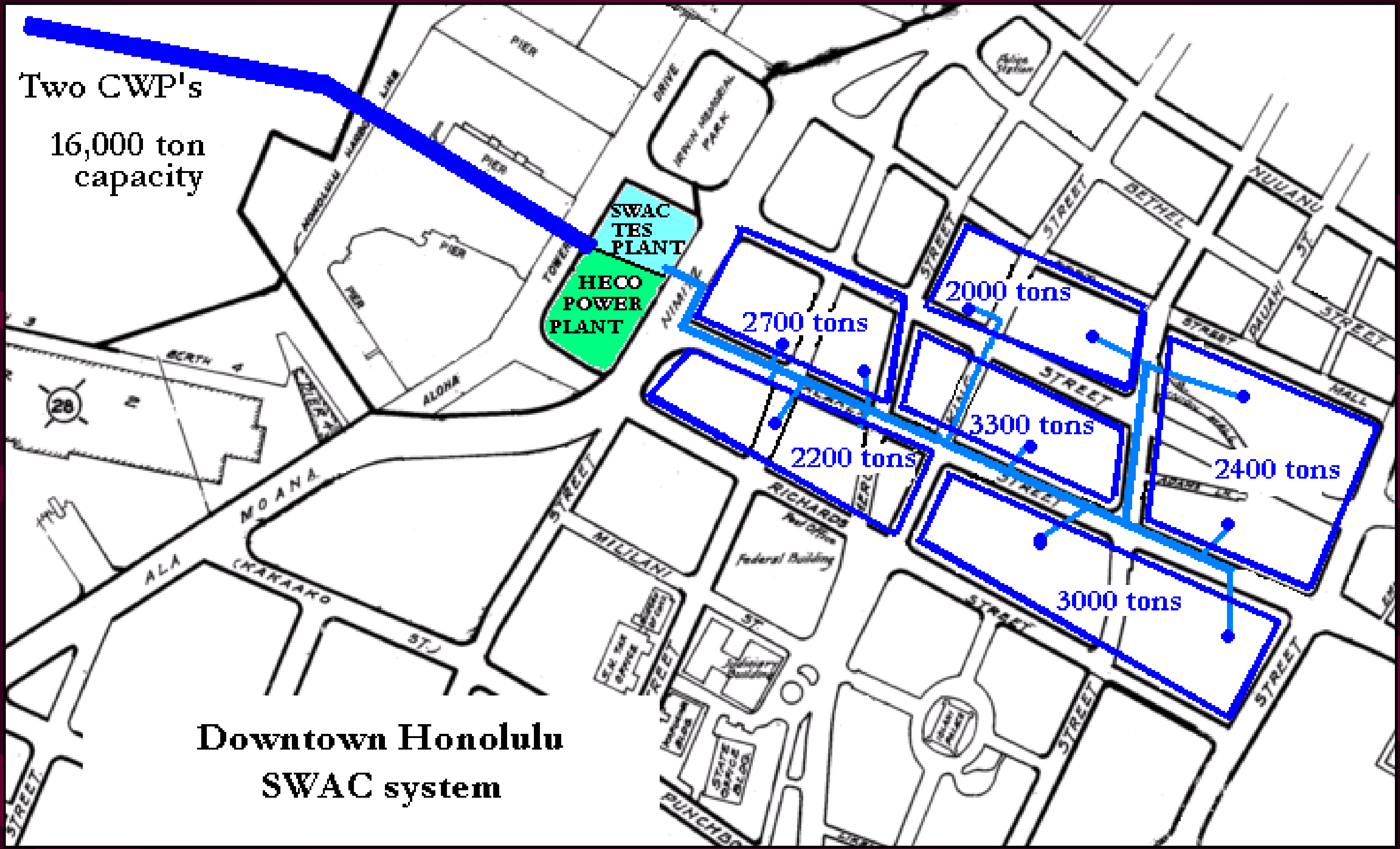
Downtown Heat Map



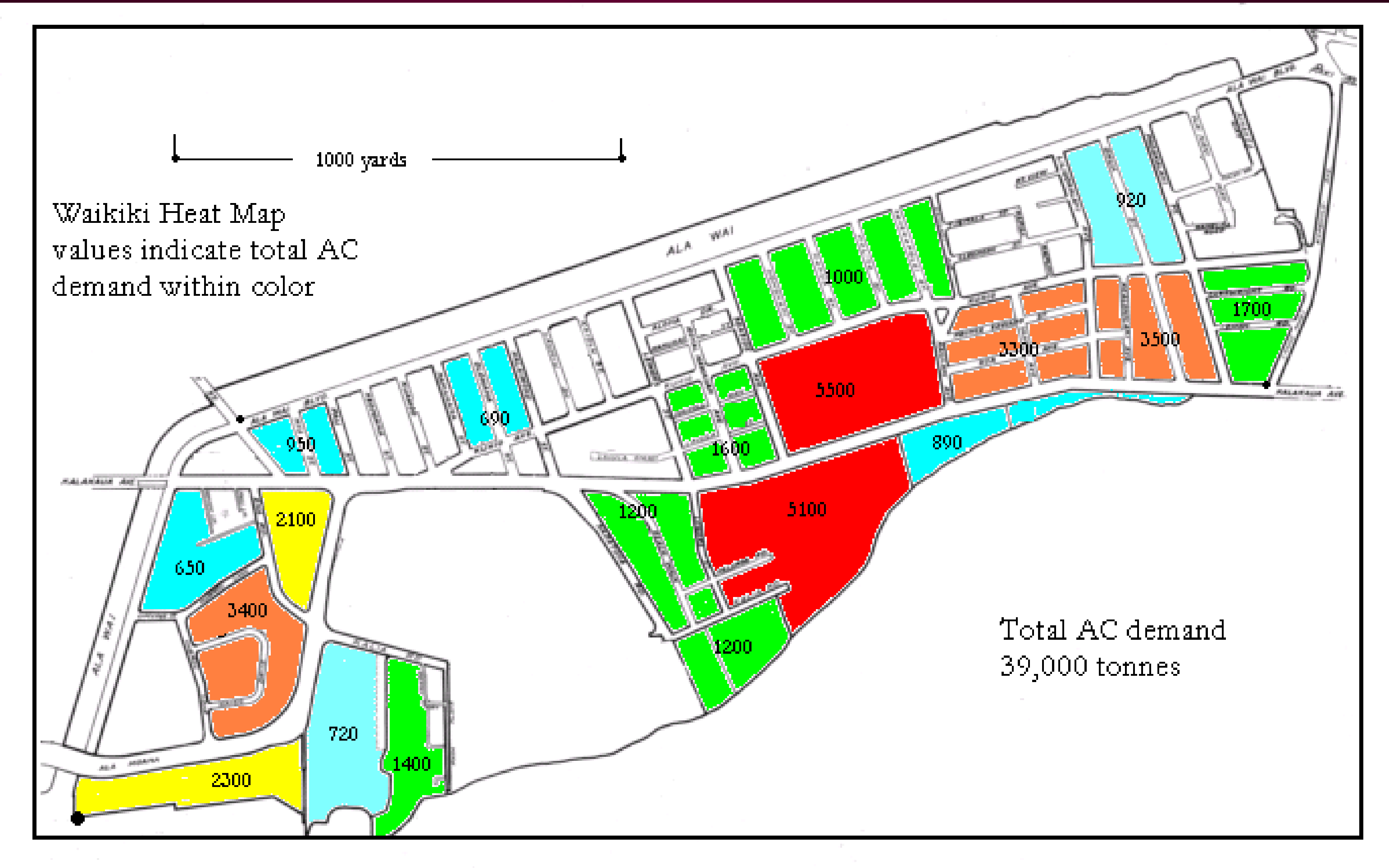
Total AC demand
21,000 tonnes

Downtown Heat Map
Values indicate total AC demand within color

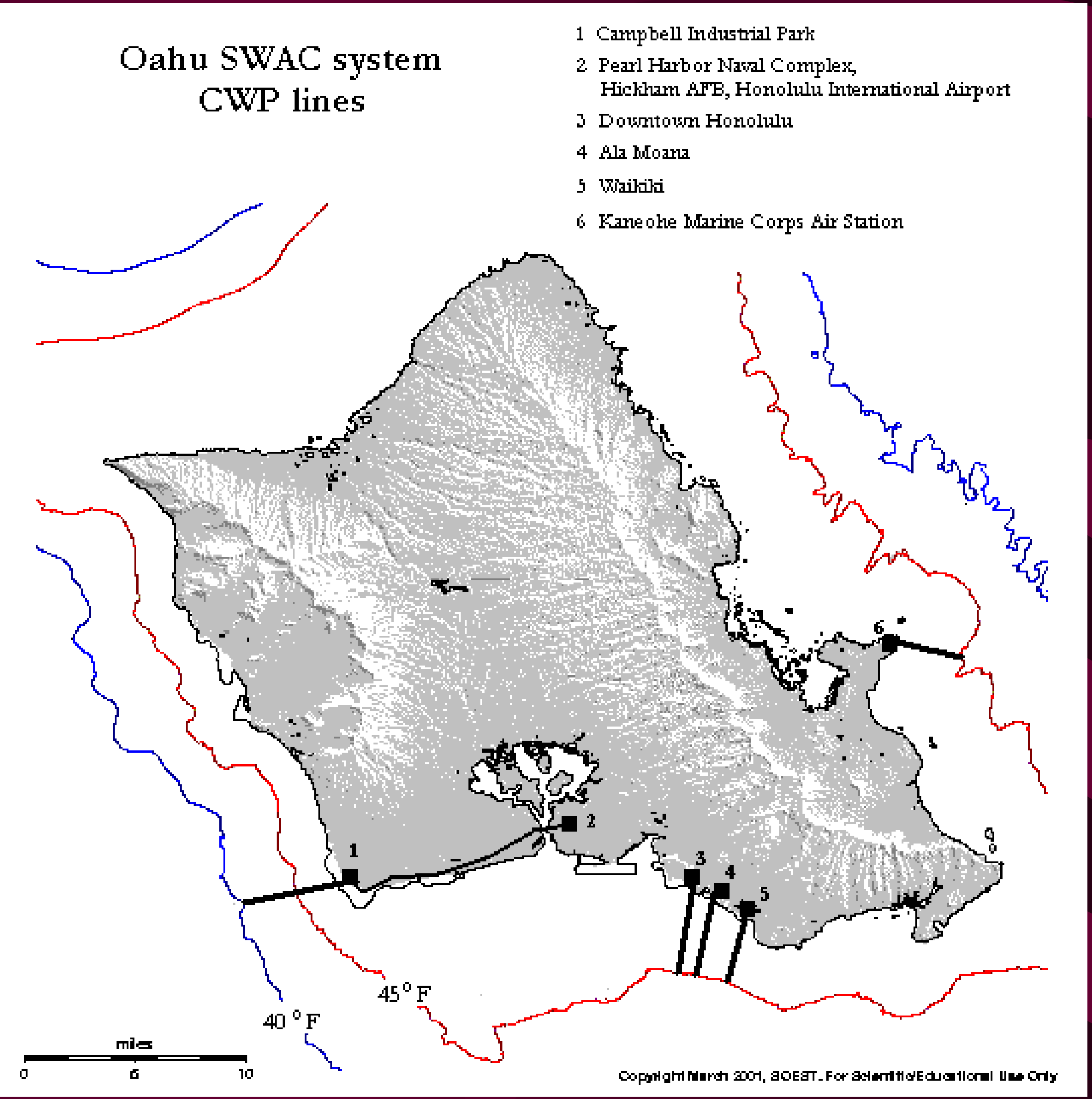
Downtown Honolulu SWAC System



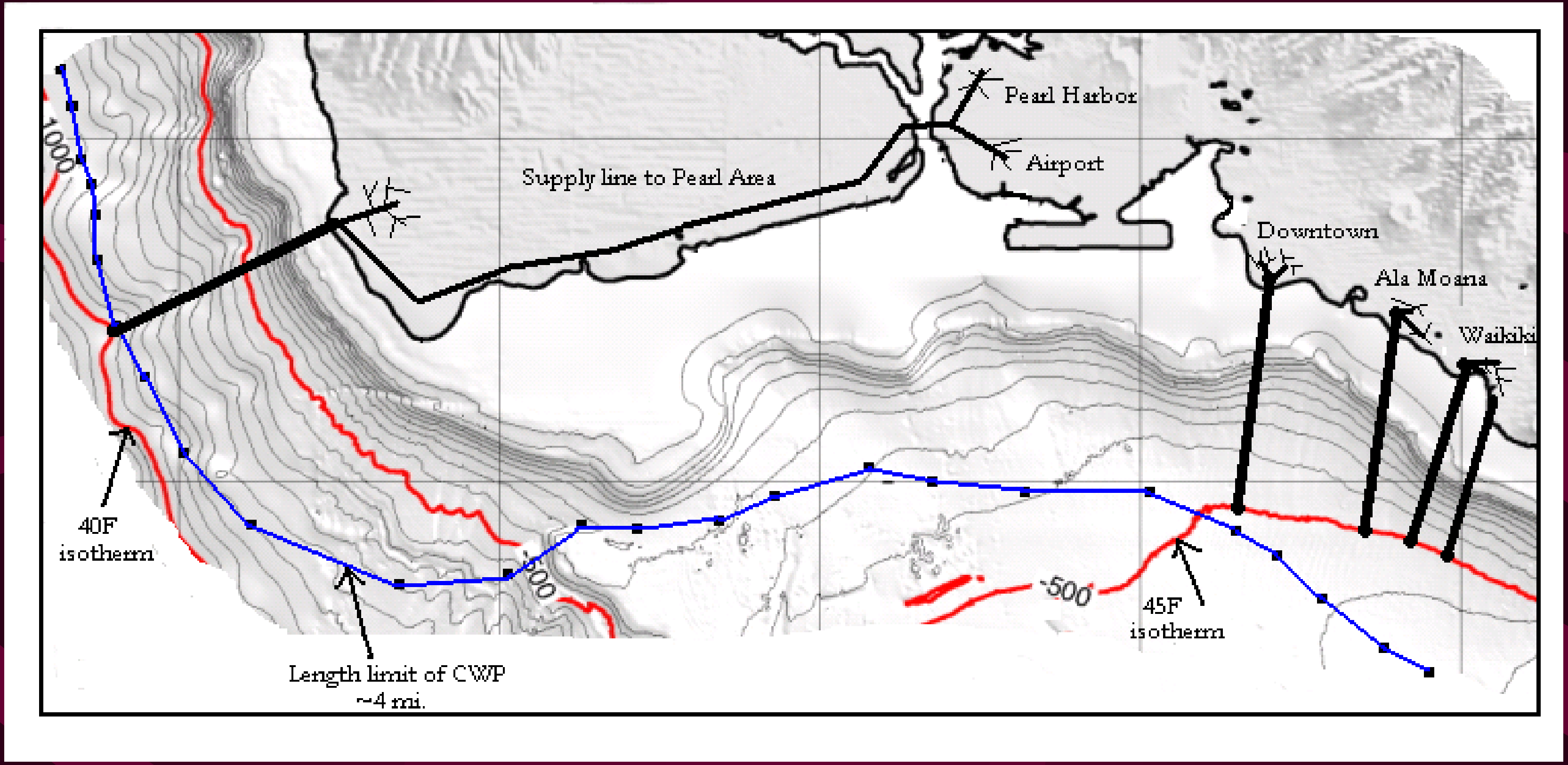
Waikiki Heat Map



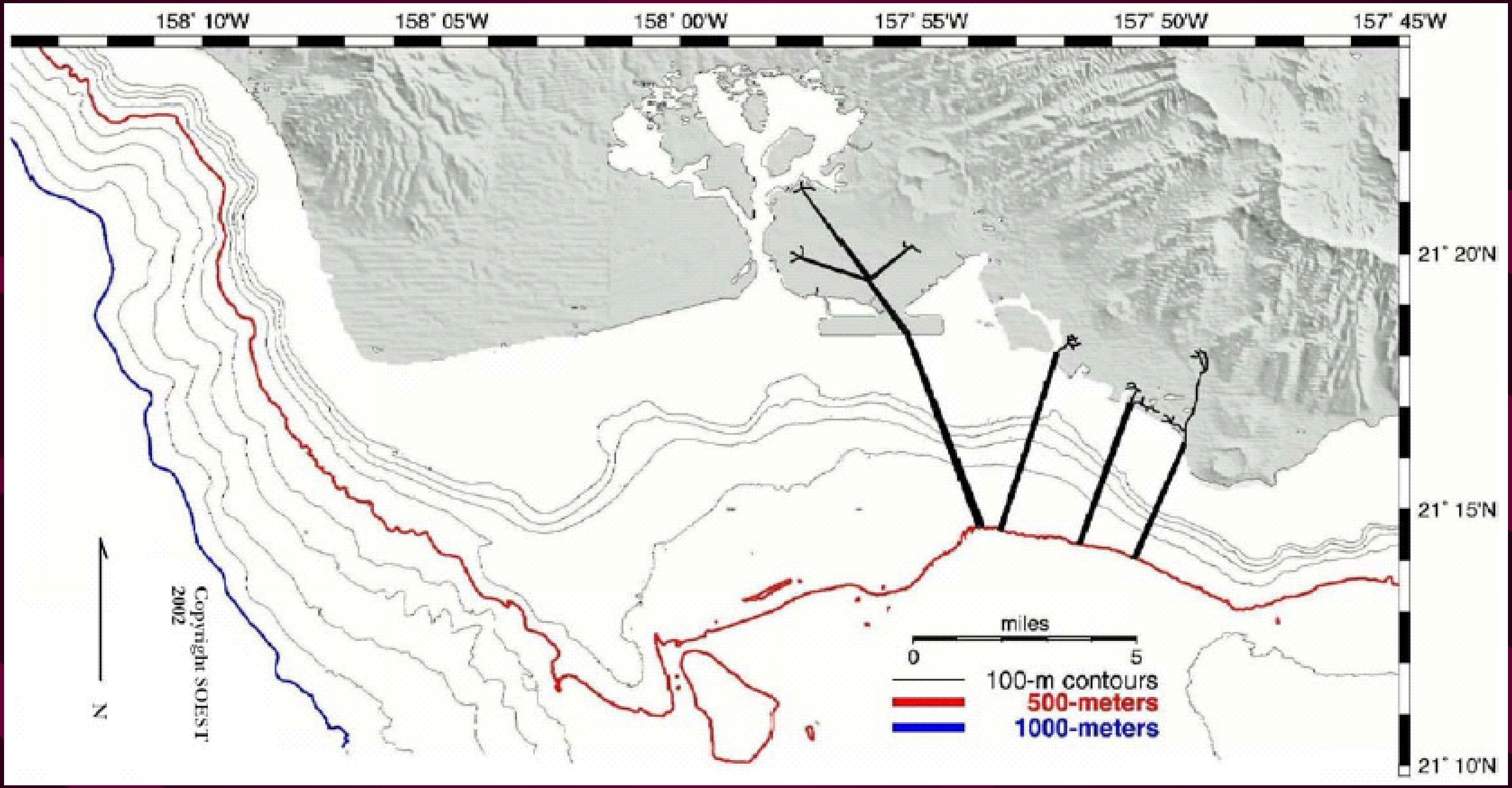
Oahu SWAC System CWPs



South Oahu CWPs – Version 1



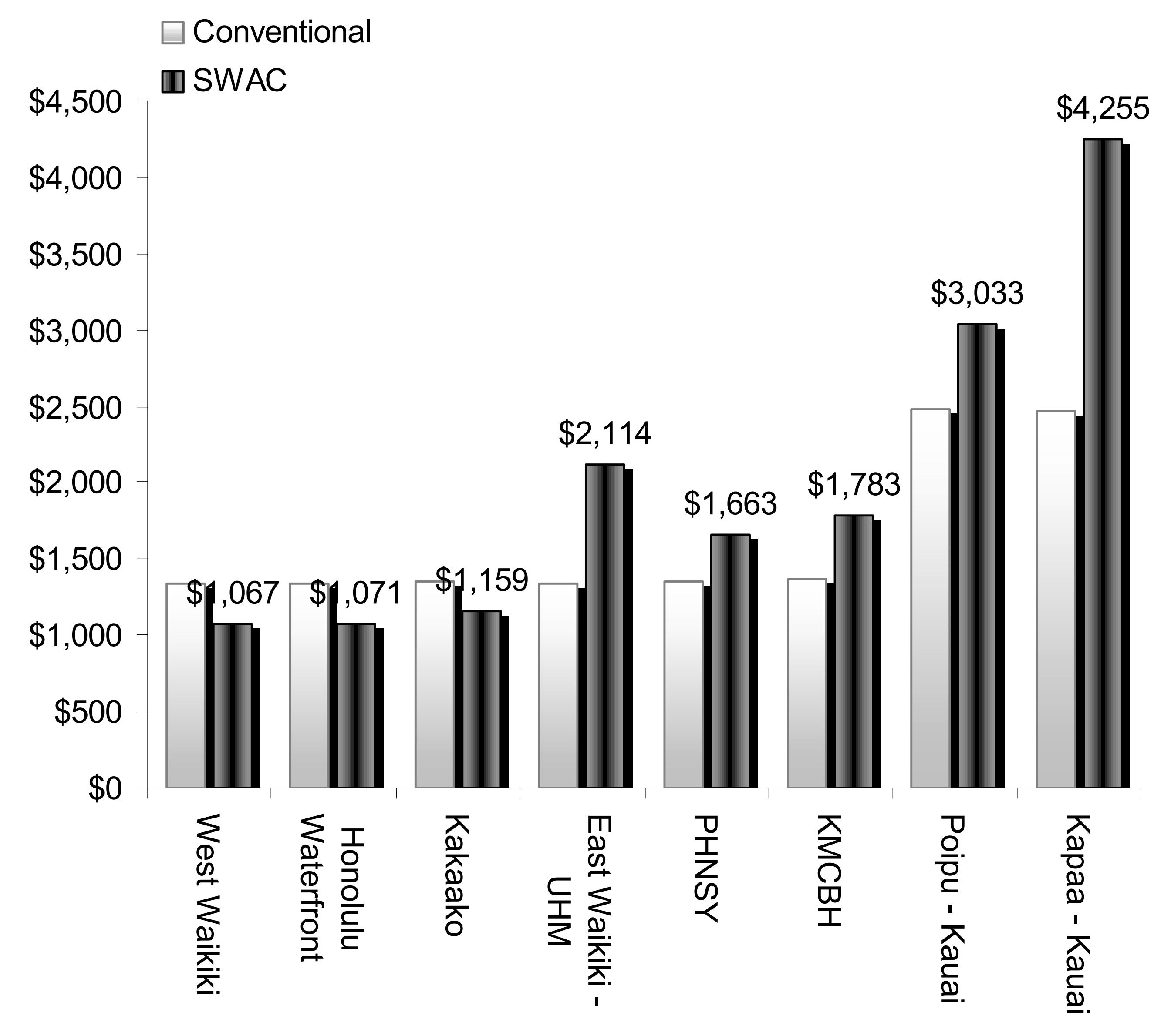
South Oahu CWPs – Version 2



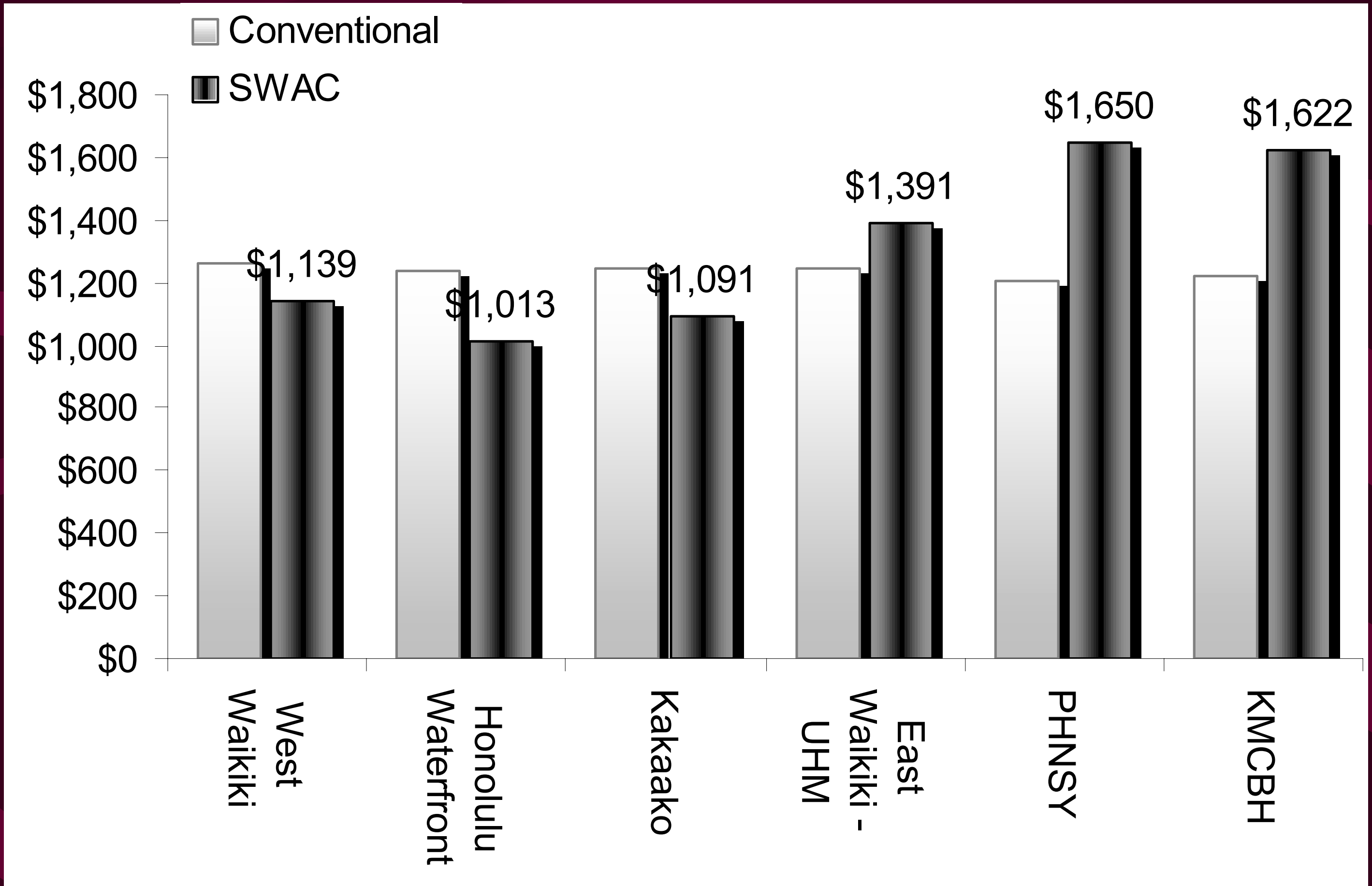
Economic Analysis Parameters

Parameter	Used	
	CCS	SDC
FINANCING		
Constant dollar	Yes	Yes
Straight line depreciation	Yes	Yes
Debt ratio (%)	100.0	100.0
Preferred ratio (%)	0.0	0.0
Common ration (%)	0.0	0.0
COST OF MONEY		
Real cost of debt (%)	7.00	7.00
Real cost of preferred stock (%)	N/A	N/A
Real cost of common stock (%)	N/A	N/A
Annual inflation rate (0 if constant dollars) (%)	0.00	0.00
Real annual escalation rate (Non-electric) (%)	0.00	0.00
Real annual escalation rate (Electric) (%)	2.00	2.00
Computed discount rate (After tax) (%)	7.00	7.00
Computed discount rate (Before tax) (%)	7.00	7.00
TAXES		
Combined federal & state income tax (%)	0.00	0.00
Combined property tax & insurance rate (%)	2.00	2.00
INITIAL CONSTRUCTION COST		
Total plant construction (TPC)	Varies	Varies
% of TPC expended in construction year 1	5	15
% of TPC expended in construction year 2	95	85
Startup costs (Land, Inventory, Startup)	0	0
OPERATING COSTS	Varies	Varies
Cost of electricity ($/kWh)	0.112	0.112
Annual energy cost	Varies	Varies
Annual non-energy O&M costs	Varies	Varies
OPERATION		
Total rated cooling capacity	Varies	Varies
Capacity factor of cooling system	0.62	0.62
REPAIR & REPLACEMENT COSTS	Varies	Varies
CONTINGENY (%)	0	20

Scenario Summary and Ranking (All Sites)



Scenario Summary and Ranking (Oahu Sites)



Sensitivity Analyses

- Each of the six case study SWAC systems was further analyzed to determine the impact of changes in various parameters involved the economics of SWAC systems and CCSs
- The impact of combinations of changes in two, or more, of these parameters was also investigated

Sensitivity Analyses Parameters

- System Lifetimes (5 – 40 years)
- Estimated Percent Replacement of CCSs
- Real Interest Rates
- Contingency Costs
- Electricity Costs
- Real Annual Electricity Cost Escalation Rates
- Combined State & Federal Income Taxes
- Federal Investment Tax Credit
- System Depreciation Methods
- Utility Rebates
- Hawaii Energy Conservation Income Tax Credit
- Production Incentives
- Combined Property Tax & Insurance Rates

Honolulu Waterfront Case Study Sensitivity Analyses

	Cost ($/ton-yr)	% Diff. from CCS Base Case
CCS Base Case w/ Conventional Financing @ 7.00%	$1,341.68	
Using 5%/year New Construction	$1,384.68	
+ 20% Contingency	$1,415.51	
+ @ 1.6% Real Annual Escalation Cost (Electricity)	$1,379.56	
+ @ 38.9097% Combined State and Federal Income Tax	**$1,388.17**	
SDC Base Case w/ Conventional Financing @ 5.50%	$958.58	-30.9
+ @ 1.6% Real Annual Escalation Cost (Electricity)	$982.75	-29.2
+ @ 38.9097% Combined State and Federal Income Tax	**$971.93**	-30.0
w/ 10% Federal Investment Tax Credit (FITC)	$882.00	-36.5
w/ Utility Rebate = $612.66/rated ton (UR)	$890.36	-35.9
w/ Federal Modified Accelerated Cost Recovery System (MACRS)	$891.00	-35.8
w/ 10% Energy Conservation Income Tax Credit (ECITC)	$907.18	-34.6
w/ 20% Energy Conservation Income Tax Credit (ECITC)	$842.43	-39.3
w/ 35% Energy Conservation Income Tax Credit (ECITC)	$745.31	-46.3
w/ 50% Energy Conservation Income Tax Credit (ECITC)	$648.18	-53.3
w/ 50% Reduction in Local Property Tax (RiPT)	$937.11	-32.5
w/ 100% Reduction in Local Property Tax (RiPT)	$902.28	-35.0
w/ 10% FITC + MACRS	$811.38	-41.6
w/ 10% FITC + MACRS + UR	$750.57	-45.9
w/ 10% FITC + MACRS + UR +35% ECITC	$601.60	-56.7
w/ 10% FITC + MACRS + UR +35% ECITC + 50% RiPT	$566.77	-59.2

Case Study Results

- SWAC systems in the Waikiki, Kakaako, and Honolulu Waterfront areas are very cost effective, even in the base case analyses
- On a weighted average basis, West Waikiki, Kakaako, and Honolulu Waterfront have base case levelized costs that are 18.4% less than CCSs
- Best case scenarios show potential levelized cost savings greater than 58%
- Even for some of the other non-Oahu case studies, various incentives would make them cost effective when compared to CCSs

Energy Savings and Avoided Generation Capacity

- SWAC systems save more than 90% of the energy used for CCSs
- On a weighted average basis, the West Waikiki, Honolulu Waterfront, and Kakaako case studies saved 92.5% of the energy typically used in CCSs
- Similar reductions in future utility electricity generation capacity are also provided
- This is equivalent to 4,526 kWh/rated ton-yr, or 8.43 Bbl of imported crude oil/rated ton-yr

Summary of the Benefits of SWAC Systems

	Total or Weighted Average	HWF	EWUHM	WW	KK	PHNS	KMCBH
Capital Cost ($1,000s)	$274,955	$41,166	$77,506	$39,568	$38,982	$42,619	$35,114
Rated Capacity (tons)	41,525	8,465	7,800	8,310	7,250	5,500	4,200
Annual Energy Saving (MWh/yr)	185,794	38,371	34,606	37,621	32,753	23,951	18,492
Annual Energy Saving (%)	91.45	92.57	90.60	92.45	92.42	89.09	90.07
Annual LSRFO Savings (Bbl/yr)	311,734	64,381	58,063	63,123	54,954	40,186	31,027
Per Rated Ton	7.51	7.61	7.44	7.60	7.58	7.31	7.39
Lifetime LSRFO Savings (Bbl)	6,234,684	1,287,622	1,161,262	1,262,451	1,099,089	803,728	620,532
Per Rated Ton	150.14	152.11	148.88	151.92	151.60	146.13	147.75
Annual Crude Oil Sav's (Bbl/yr)	337,909	69,787	62,938	68,423	59,569	43,561	33,632
Per Rated Ton	8.14	8.24	8.07	8.23	8.22	7.92	8.01
Lifetime Crude Oil Sav's (Bbl)	6,758,183	1,395,737	1,258,768	1,368,454	1,191,375	871,214	672,635
Per Rated Ton	162.75	164.88	161.38	164.68	164.33	158.40	160.15
Equivalent SWH System (energy)	66,402	13,536	12,473	13,288	11,593	8,795	6,716
Equivalent SWH System (capac.)	52,089	10,618	9,784	10,424	9,094	6,899	5,268

Other Benefits of SWAC Use

- Other benefits of such a large reduction in imported fossil fuels use include:
  - Significant reduction in greenhouse gas emissions and other air and water pollutants
  - Does not use potentially harmful working fluids (such as the ones used in many CCSs)
  - Greatly reduces the water and toxic chemical use and disposal associated with cooling towers

Secondary Uses of SWAC Effluent

- Economically and environmentally beneficial uses of the exhausted seawater may also be possible, as the seawater is still relatively cold at 55° F to 57° F
  - Effluent water can be used at a marine biotechnical industrial park/facility, as auxiliary cooling water for conventional power plants or industrial processes, for cooling of grounds, e.g. parks and golf courses
  - Effluent may also be discharged into brackish bodies of water, estuaries, canals and harbors to provide flushing and improvement in water quality

Cold Seawater as a Heat Sink

- Candidates for the use of the effluent seawater
  - Refrigeration, fluid cooling, and other systems requiring the use of cooling towers, evaporative condensers, or even air cooled condensers
  - Utility power plant cooling

Cooling Towers

- Use of the chilled water, or the slightly warmer return flow, could be used to increase the efficiency of cooling towers and chillers
- Less power will be required for cooling tower fan motors and condenser water pumps
- Chiller lift (chiller internal differential temperature) will decrease and efficiency will increase

Power Plant Cooling

- Effluent seawater from a SWAC system is still relatively cold (~57^{o}F)
- Average cooling water temperature in Hawaii is 77^{o}F
- Effluent seawater could be mixed with existing cooling water
- Using this lower temperature cooling water results in an increase in efficiency

Power Plant Cooling (cont'd)

- Downtown Honolulu has been suggested as a site for a SWAC district cooling system
- A mixture of effluent seawater and existing cooling water could be used HECO's 113-MW Honolulu power plant
- Based on a SWAC system size of 10,000 to 20,000 tons, this could:
  - Provide 50 to 80% of the cooling requirements
  - Reduce cooling water inlet (and outlet) temperatures by 6-12^{o}F

Cool and Cold Water Aquaculture and Agriculture

- Effluent seawater can also be used for cool and cold water aquaculture and agriculture
- Lack of land availability would likely prevent this for any urban Honolulu SWAC systems
- It may be feasible for neighbor island systems (if sufficient land is available)
- This dual-use application may help to make these smaller systems more cost-effective

Water Quality Improvement

- Ala Wai Canal
  - Effluent seawater from a Waikiki SWAC system will help to flush the canal and to improve the water quality
- Honolulu Harbor
  - Effluent seawater from a downtown Honolulu SWAC system will help to flush Honolulu Harbor and improve its water quality

Ala Wai Canal

Source:
Honolulu
Star-Bulletin

Ala Wai Junk

Source: Honolulu Star-Bulletin

Conclusions

- A typical SWAC system is quite simple and is suitable for coastal developments with large air conditioning demand and reasonable access to deep, cold seawater
- SWAC systems are both technically and economically feasible today and, once installed, the energy supply is inexhaustible, renewable, and with minimal environmental impacts

Conclusions (cont'd)

- SWAC systems have great potential in Hawaii
- All islands have some shorelines that have good access to deep cold seawater and Hawaii has a year-round, relatively uniform need for air conditioning
- Hawaii has an estimated SWAC potential of more than 100,000 tons, with more than 50,000 tons of this potential in the Waikiki/Kakaako/downtown Honolulu area

Conclusions (cont'd)

- Sensitivity analyses conducted show that SWAC systems in the Waikiki, Kakaako, and Honolulu Waterfront areas are very cost effective, even in the base case analyses
  - On a weighted average basis, case study systems (West Waikiki, Kakaako, and Honolulu Waterfront) have base case levelized costs that are 18.4% less than CCSs
  - Best case scenarios show potential levelized cost savings greater than 58%
  - Even for some of the other non-Oahu case studies, various incentives would make them cost effective when compared to CCSs

Conclusions (cont'd)

- Savings of these magnitudes could justify a significant reduction in cooling costs to SWAC system customers, while still providing developers with a good return on investment
- Other benefits include significant greenhouse gas reduction and other air and water pollution benefits
- A SWAC system also does not use potentially harmful working fluids (such as the ones used in many CCSs) and greatly reduces the water useful and toxic chemical use and disposal associated with cooling towers

Conclusions (cont'd)

- Economically and environmentally beneficial uses of the exhausted seawater may also be possible, as the seawater is still relatively cold at 55° F to 57° F
  - As a Heat Sink
    - Cooling Towers
    - Power Plants
  - Cool and Cold Water Aquaculture and Agriculture
  - Water Quality Improvement

Conclusions (cont'd)

- The best system for Hawaii (and possibly other areas) might be a hybrid SWAC/Thermal Energy Storage (TES) system
- A SWAC/TES system would allow greater utilization of the SWAC system by increasing its capacity factor
- The SWAC system would supply a much larger base load cooling demand (for a given pipe size and cost), and the TES system would supply the peak demand
- A smaller TES system would provide peaking capabilities for a much larger district cooling system
- Utility demand during peak demand periods would be reduced significantly and energy use would be reduced by 80 - 90%

Recommendations

- A follow-up study should be conducted to evaluate the potential for integrating SWAC systems with energy storage systems. (This study is currently underway.)

- There is also a need to conduct more-detailed,site-specific evaluations for each of the positive and marginal sites identified in this study

The full text of this report can be found at:

- http://www.hawaii.gov/dbedt/ert/swac.html

Aloha